NISTTech

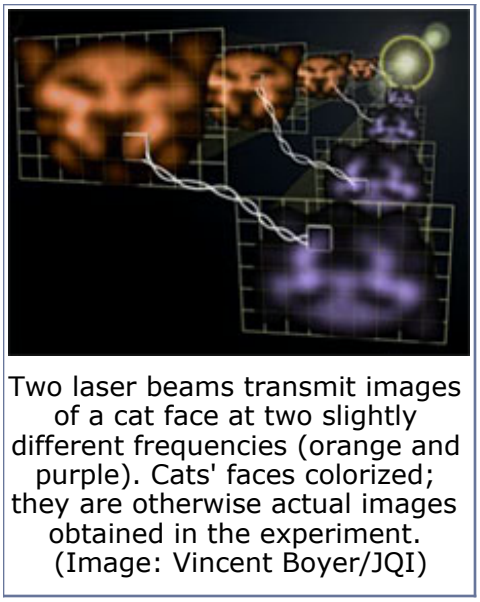
Improved Optical Image Processing Using Squeezed Light

Four-Wave Mixing Source of Squeezed Light for Image Processing & Interferometry

Description

Amplify images noiselessly and produce an entire image at one time using squeezed light. This invention can make a wide variety of images in any shape by manipulating and processing optical beams with quantum characteristics (squeezed light). The quantum images are in "entangled" pairs, which are transmitted by two light beams originating from the same point. The new method, which takes advantage of the quantum-mechanical aspects of images, has wide-applications ranging from taking pictures of hard-to-see objects, to super-resolution and faint object amplification in microscopy, to storing data in futuristic quantum computers.

Images



Two laser beams transmit images of a cat face at two slightly different frequencies (orange and purple). Cats' faces colorized; they are otherwise actual images obtained in the experiment. (Image: Vincent Boyer/JQI)

Applications

- **Spectroscopy**
  Very stable and highly sensitive chemical detection for photo thermal spectroscopy.
- **Microscopy**
  Allows imaging of weak data and image recovery.
- **Quantum computing and data security**

Stores patterns of data in quantum computers and transmits large amounts of highly secure encrypted information.

Advantages

- **Secure quantum computing**
  Stores patterns of data in quantum computers and transmits large amounts of highly secure encrypted information.
- **Improved efficiency**
  Simplicity, versatility, and efficiency in processing that allows improved amplification and positioning of light beams.
- **Better imaging**
  Enables better detection of faint objects, noiseless image amplification and use of super-resolution techniques.

Abstract

The phase-sensitive amplifier implementing our chi(3) 4-wave mixing source would be an enabling technology for image processing. A number of efforts in the newly labeled field of "quantum imaging" allow for better detection sensitivity or better image resolution if one is able to apply "squeezed" light with a broad range of spatial modes and frequencies. Such nonclassical light (a quantum mechanical treatment of the electromagnetic field is required) has proved difficult to produce in the past. Our present source is competitive with, but not quite as good as, the best available chi(2)-based systems in the degree of squeezing we have obtained. On the other hand, it is clearly superior to them in its ability to produce squeezed light in many spatial modes of the field. It will allow "noiseless image amplification" and "super-resolution" techniques to be employed in applications well beyond what has been demonstrated with chi(2) media. It should have uses in microscopy and image recovery from weak image data. In addition, a diode-based source should demonstrate squeezing at very low detection frequencies. This should allow the production of a very stable interferometer using our 4-wave mixing source. Such an interferometer would be an excellent detector for highly sensitive chemical detection by photothermal spectroscopy.

Inventors

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Citations

1.

1. V. Boyer, A. Marino, R. Pooser, and P. Lett. Entangled Images from Four-Wave Mixing. *Science Express*, 12 June 2008

   Physicists Produce Quantum-Entangled Images: Convenient, Versatile Technique Could Provide New Tool for Quantum Information, Better Optical Measurements, Techbeat, June 12, 2008

2. C. F. McCormick, V. Boyer, E. Arimondo, and P.D. Lett. Strong relative intensity squeezing by four-wave mixing in rubidium vapor. OPTICS LETTERS, Vol 32, No 2, January 15, 2007.

Related Items

- Physicists Produce Quantum-Entangled Images
- Poster Presentation: A Source of Correlated Photons and Atoms

References

- U.S. Patent # 7,453,626
- Docket: 07-008

Status of Availability

This invention is available for licensing.

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